

# Deductive Reasoning and Social Anxiety: Evidence for a Fear-confirming Belief Bias

Maartje S. Vroling · Peter J. de Jong

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**Abstract** This study investigated the relationship between belief bias and fear of negative evaluation. Belief bias refers to a bias in deductive reasoning that acts to confirm rather than falsify prior beliefs. Participants ( $N = 52$ ) with varying levels of fear of negative evaluation completed a belief bias task by means of linear syllogisms, with stimuli covering both social anxiety convictions and factual neutral statements. A linear relationship was found between fear of negative evaluation and belief bias for the social anxiety conviction category. No differences in reasoning were found for the neutral syllogisms. These results support the view that highly socially anxious individuals do not have a reasoning abnormality, but do have difficulty judging anxiogenic information as false and reassuring convictions-contradicting information as true. Such belief bias logically prevents dysfunctional cognitions from being corrected, thereby sustaining phobic fear.

**Keywords** Belief bias · Social anxiety disorder · Syllogistic reasoning · Dysfunctional cognition · Cognitive bias · Fear of negative evaluation

## Introduction

Dysfunctional cognitions about rejection or shame are central in social anxiety disorder. The fear stemming from

these convictions leads to a range of behaviours characteristic of social anxiety disorder (Clark and Wells 1995; Rapee and Heimberg 1997). Current cognitive models emphasize the role of information processing biases such as judgmental bias, attentional bias and interpretation bias in maintaining socially anxious convictions (for reviews see Bögels and Mansell 2004; Clark and McManus 2002; Hirsch and Clark 2004). The major focus of current treatment strategies (e.g., Clark and Wells 1995; CPA 2006; Trimbos-instituut 2003) is to somehow challenge these convictions in an attempt to replace dysfunctional and oftentimes irrational beliefs by more rational ones. The alleged crucial role of irrational beliefs in the persistence of complaints points to the vital importance of individuals' ability to draw adequate conclusions. The inability to draw appropriate conclusions on the basis of available evidence seems a particularly direct way to impede the adjustment of irrational, anxiogenic beliefs. In cognitive psychology, the relatively poor performance in drawing appropriate conclusions when reasoning with materials that are counterintuitive (i.e., have a mismatch between the believability and the logical validity) is known as the belief bias effect. Despite its apparent importance, the ability to evaluate (dysfunctional) beliefs in light of evidence has received little attention in psychopathology research.

Belief bias refers to a bias in deductive reasoning that acts to confirm rather than falsify prior beliefs, which is demonstrated in a tendency to endorse a priori believable conclusions as valid and unbelievable conclusions as invalid, regardless of their actual logical status (Evans et al. 1993a). It is assumed to facilitate the maintenance of a relatively stable belief system from which the world and experiences can be interpreted without great effort, leaving the attentional capacities for more urgent and complex tasks. Therefore, in everyday life some degree of belief

M. S. Vroling (✉) · P. J. de Jong  
 Department of Clinical and Developmental Psychology,  
 University of Groningen, P.O. Box 72, 9700 AB Groningen,  
 The Netherlands  
 e-mail: m.s.vroling@rug.nl

P. J. de Jong  
 e-mail: p.j.de.jong@rug.nl

bias might be considered functional. Also in potentially dangerous situations, it may well be adaptive to rely on prior beliefs and act on plausible conclusions, rather than to consider whether those conclusions meet the standards of formal logic (e.g., Evans et al. 1993b). If, however, the perceived threat is based on dysfunctional convictions (for instance, ‘If I say something odd, people will ridicule me’), belief bias may become counterproductive. In that case, such a bias in deductive reasoning could impede the disconfirmation of anxiogenic beliefs, which in turn may lead to stable cognitions feeding the anxiety disorder (cf. de Jong et al. 1997). Accordingly, belief bias may play a fairly direct role in the maintenance of fearful preoccupations.

Belief bias can be measured using a linear syllogistic reasoning task (e.g., Smeets and de Jong 2005). In performing this task participants are asked to judge as quickly as possible the logical validity of syllogisms consisting of two statements, the premises, and a conclusion. Logical validity refers to the necessity of a conclusion, assuming that the premises are true. If it is true that ‘A is larger than B’ and that ‘B is larger than C’, it follows that ‘A must be larger than C’. Logical validity would be violated when one concludes that ‘C is larger than A’ based on the given premises. When judging the validity, participants are instructed to ignore the believability of the conclusions. Believability refers to the meaning of the syllogism’s conclusion. An example of a generally believable conclusion would be: ‘An elephant is bigger than a mouse’, whereas ‘A mouse is bigger than an elephant’ represents an example of a generally unbelievable conclusion. A valid yet unbelievable linear syllogism would be as follows:

Premise 1	A mouse is bigger than a dog
Premise 2	A dog is bigger than an elephant
Conclusion	A mouse is bigger than an elephant

Thus, participants have to judge whether a syllogism is logically valid, while ignoring its meaning. People are typically faster in reaching a decision about the validity of a syllogism when there is a match than when there is a mismatch between the validity and believability of the conclusion.

Although it seems plausible to apply the belief bias theory to dysfunctional convictions, there is a clear distinction with past research: Past studies have focussed on universal truths and common beliefs for which confrontation with disconfirming evidence is unlikely, whereas the current study focusses on the potential relevance of belief bias for dysfunctional convictions for which disconfirming evidence is oftentimes available.

In a first attempt to explore this relationship, de Jong et al. (1997) tested spider phobic participants and non-phobic controls for belief bias when reasoning with spider

phobia relevant materials. They failed to find a convincing difference between the phobic and the non-phobic group. This might well have been due to methodological problems. Most important, spider phobia relevant beliefs (e.g., as indexed by the Spider Phobia Questionnaire by Arntz et al. 1993) are hard to translate into linear syllogisms, which are based on comparison (e.g., A spider is creepier than a fish, a fish is creepier than a pigeon, hence a spider is creepier than a pigeon). The necessary inclusion of a comparison category decreases the resemblance between the syllogisms’ conclusions and the dysfunctional beliefs, thereby probably decreasing the sensitivity of the task. In addition, it is doubtful whether spider phobia is the optimal candidate for testing this hypothesis. Although there is evidence that spider phobic individuals do report high believability ratings for irrational spider related beliefs (e.g., ‘the spider will kill me’; Arntz et al. 1993; Thorpe and Salkovskis 1995), it is still a matter of dispute whether dysfunctional beliefs indeed play a crucial role in the aetiology and maintenance of the phobic complaints. Some authors described spider phobia as a prototypical “non-cognitive” (evolutionary prepared) fear (e.g., Seligman 1971). Accordingly, spider fearful individuals find it extremely difficult to articulate what they actually fear (e.g., Davey 1992).

Therefore, the present study focussed on social anxiety (rather than spider phobia) to test further the potential role of belief bias in anxiety disorders. Dysfunctional beliefs are generally assumed to be central to social anxiety disorder (e.g., Clark and Wells 1995), and a striking feature of these beliefs is their persistence in the face of incompatible data. That is, because socially anxious individuals cannot so easily avoid the situations they strongly fear (as spider phobic individuals can), most socially anxious individuals will have been involved in many social situations that contradicted their fearful convictions (e.g., situations in which they are not ridiculed for saying something odd). Moreover, social anxiety beliefs often imply social comparison, making social anxiety convictions more suitable for translation into linear syllogisms (e.g., ‘I am not likeable’ translates into ‘I am less likeable than others’ or into a linear syllogism such as ‘I am less likeable than Jane and Jane is less likeable than John’). The main aim of the present study was thus to test the hypothesis that socially anxious individuals are characterized by belief bias when reasoning about social anxiety themes. Therefore, a group of individuals varying in their level of fear of negative evaluation (one of the central cognitive concepts within social anxiety, e.g., Clark and Wells 1995) was presented with a series of linear syllogisms concerning themes relevant to social anxiety.

If enhanced belief bias is only evident for dysfunctional convictions, this would be consistent with the idea that the

rigidity of anxiogenic beliefs may not itself result from a reasoning abnormality, but may represent a normal tenacity of important and strongly held beliefs (cf. Garety and Hemsley 1997). Yet, research in the context of spider phobia (de Jong et al. 1997) provided preliminary evidence to suggest that psychopathology patients show a generally enhanced belief bias (i.e., not restricted to the domain of the psychopathological concerns). This raises the possibility that this reasoning bias reflects a trait-like information processing bias that acts as a diathesis in the development of psychopathological disorders in general (cf. Arntz et al. 1995). As a subsidiary issue it was therefore tested whether socially anxious individuals are (also) characterized by enhanced belief bias for factual information that is irrelevant for their social anxiety concerns.

To summarize, content interferes with logical reasoning when reasoning with highly believable materials. As socially anxious people hold strong social anxiety convictions, one can expect to find a belief bias effect concerning social anxiety related materials for the high social anxiety group and not for the low social anxiety group. In addition to this content-specificity hypothesis, it is explored, based on the earlier finding by de Jong et al. (1997), whether high socially anxious people have a general tendency to apply belief bias more often compared to low anxious people. Therefore, we also tested whether socially anxious individuals will show a relatively strong belief bias when reasoning with neutral, generally believable, materials.

## Method

### Participants

As part of their course requirement, first-year psychology students ( $N = 339$ ) participated in a mass-screening during the start of the first semester. The majority of these students ( $N = 234$ ) gave permission to contact them for further research.<sup>1</sup> On the basis of their scores on the brief Fear of Negative Evaluation scale (BFNE, Leary 1983; for more details see below) we pre-selected extreme groups. High and low scoring students on the scale were approached for the current study, six months after the mass screening. Participants from the extreme ends of the distribution of the BFNE scores were contacted until 30 students<sup>2</sup> were willing to participate for each group (to include 30 willing

participants per group, 25% of the lowest scoring participants and 20% of the highest scoring participants were contacted; BFNE scores ranged from 1 to 15 and 30 to 48, respectively). Of these 30 participants, 26 of each group showed up at the lab. The final sample consisted of 15 men (7 high anxiety and 8 low anxiety) and 37 women (19 high anxiety and 18 low anxiety), with a mean age of 20 ( $SD = 1.65$ ). Participants received course credits, or a small financial reward if they had already fulfilled course requirements.

Participants again completed the BFNE as part of the experiment. Unexpectedly, participants' BFNE scores during the actual experiment no longer showed a bi-modal distribution. In fact, participants' BFNE scores were now distributed over almost the entire range of the BFNE (range = 1–42,  $M = 22.65$ ,  $SD = 11.37$ ,  $P25 = 13.5$ ,  $P50 = 22.5$ ,  $P75 = 33.75$ ). The average BFNE scores of untreated Dutch social anxiety disorder patients in the Netherlands is around 34<sup>3</sup> (e.g., Voncken et al. 2003,  $M = 33.9$ ; Voncken et al. 2007,  $M = 28.7$ – $38.0$ ; Bögels et al. 2006,  $M = 36.67$ ). Looking at the percentiles of our distribution, we can thus conclude that about 25% of the BFNE scores that were assessed on the day of the experiment were as high as or higher than the average social anxiety disordered patient score. A paired sample  $t$ -test revealed no changes in average BFNE score over time ( $M_{\text{preselection}} = 23.87$ ,  $M_{\text{experiment}} = 22.65$ ,  $t(51) = 1.01$ ,  $p = .317$ ).

### Materials and Apparatus

#### Syllogistic Reasoning Task

Linear syllogisms in the form 'a > b, b > c, therefore a > c' were constructed for the social anxiety convictions domain. In an attempt to cover the most relevant convictions eight topics were selected based on the Social Phobia Beliefs Questionnaire (SPBQ,<sup>4</sup> e.g., *I am more vulnerable than others in social situations*, *Everybody watches me in social situations*, and *I am less skilled than others in social situations*; List based on description of cognitions in social anxiety by Beck et al. 1985). To rule out the possible influence of idiosyncratic associations between particular names and particular characteristics, the terms 'person 1' and 'person A' were used rather than concrete names as the neutral reference persons in the syllogisms. Each topic was presented in two perspectives: a public self-referent (e.g.,

<sup>1</sup> These students did not differ in their BFNE-scores (yes-permission BFNE = 22.6, no-permission BFNE = 22.0,  $t(337) = .63$ ,  $P > .05$ ).

<sup>2</sup> Power-analysis indicated that with an expected large effect and with 80% power and  $\alpha = .05$ ,  $n$  per group should be at least 25. Anticipating potential technical problems during data acquisition and/or participants not showing up, it was decided that 30 subjects should be selected per group.

<sup>3</sup> The Dutch BFNE uses a 0–4 scale, whereas some English versions use a 1–5 scale. This explains the seemingly large differences in Dutch and English-speaking patients' BFNE scores.

<sup>4</sup> The psychometric properties of the SPBQ are reported in an unpublished master-thesis (Bezemer 1995).

*Others find me less interesting than person 1*) and a private self-referent (e.g., *I am less interesting than person 1*) perspective. This was done because the literature seems unclear in whether social anxiety disorder concerns negative public or private self-referent convictions, or both (e.g., Mansell and Clark 1999; Hofmann and Scepkowski 2006), and to ensure targeting the convictions that are most relevant for social anxiety patients. See Appendix 1 for a list of all social anxiety congruent convictions syllogisms that were used in this study.

To test reasoning with factual (neutral) materials, eight complaint-irrelevant, neutral syllogisms were included that refer to common knowledge (e.g., *A leopard is faster than a human being. A human being is faster than a snail. Therefore, a leopard is faster than a snail*). See Appendix 2 for a list of all neutral syllogisms that were used.

Traditionally, the belief bias effect has been defined as the interaction between logical validity and believability, with higher latencies and more errors for syllogisms that are valid yet unbelievable and syllogisms that are invalid yet believable (i.e., when there is a mismatch between logical validity and believability) (Evans et al. 1993a, b). In the present study, the term ‘believability’ is not used. The term ‘reality value’, with the dimensions ‘true’ and ‘untrue’, is used to refer to the content of the neutral common knowledge syllogisms and the term ‘social anxiety convictions’ (SA convictions), with the dimensions ‘SA congruent’ and ‘SA non-congruent’, to refer to the content of the social anxiety themes.<sup>5</sup> Thus for the neutral themes, a belief bias effect is manifested in the interaction between logical validity and reality value, with higher latencies and more errors when there is a mismatch between the reality value of a conclusion and its logical validity, whereas reasoning performance is enhanced (faster responding, less errors) when there is a match between a conclusion’s logical validity and reality value. The domain-specific belief bias is manifested in the interaction between the congruency of the individual’s social-anxiety-relevant convictions (social anxiety congruent or non-congruent) and logical validity of the syllogisms. Thus, for socially anxious individuals, relative poor performance (i.e., slow and more mistakes) is expected when solving SA congruent-invalid and SA non-congruent-valid syllogisms, but relatively good performance (fast and few errors) when answering SA congruent-valid and SA non-congruent-invalid syllogisms.

Each topic from the SA convictions category was presented in a SA congruent-valid, a SA non-congruent-

invalid, a SA congruent-invalid, and a SA non-congruent-valid manner. Each topic from the neutral common knowledge category was presented in a true-valid, an untrue-invalid, a true-invalid, and an untrue-valid manner; see Tables 1 and 2 for an example of each combination. For all syllogisms the two premises were presented in two orders ( $a > b$ ,  $b > c$  and conclusion  $a > c$  against  $b > c$ ,  $a > b$  and conclusion  $a > c$ ) to counter possible reading strategies that could undermine the task’s sensitivity as a measure of reasoning bias (cf. Smeets and de Jong 2005).

For the social anxiety relevant part 8 topics  $\times$  2 perspectives  $\times$  4 types  $\times$  2 premise orders = 128 syllogisms were used. For the neutral common knowledge themes 8 topics  $\times$  4 types  $\times$  2 premise orders = 64 neutral syllogisms were used. Both categories of syllogisms were presented intermixed in four blocks of trials, separated by a fixed 30-s break. Each block started with three filler syllogisms used in a previous experiment to ensure participants were focused on the task when answering the experimental syllogisms. The outcome measures were reaction time (RT) and number of errors.

Stimuli were divided over the four blocks and were presented in a fixed random order with the following restrictions—topic and perspective should differ between all consecutive stimulus presentations, a particular syllogism type (e.g., true-invalid) could not occur more than twice in a row and premise order should differ at every fourth stimulus presentation at least. To ensure that all blocks resembled each other, all syllogism topics were presented equally frequently in each block, and premise order and syllogism type were balanced as a function of category and perspective within blocks. Hence, each topic of the neutral common knowledge category was presented twice and each social anxiety relevant topic was presented twice for each perspective, public or private self-referent, per block. With these restrictions, four similar fixed random stimulus lists were created.

To counter possible carry-over effects between blocks, multiple stimulus list combinations were created. First, reversed (z–a) duplicates were made out of the four stimulus lists described above. After that, the resulting eight different lists were combined into six different list combinations. Participants were randomly assigned to one of the list combinations.

### Belief Check

To confirm that the social anxiety syllogisms were indeed congruent with social anxiety concerns, participants were asked to indicate how believable they rated the SA congruent and the SA non-congruent conclusions used in the syllogistics reasoning task. The conclusions were presented as statements on a computer screen, four at a time.

<sup>5</sup> Contrary to common practice, the term ‘believability’ is not used, because in our study, there is an important distinction between the neutral and the SA convictions themes: the neutral themes relate to factual information while the SA convictions relate to beliefs people have. For these latter themes, the factual status of the beliefs cannot be known.

**Table 1** Examples of social anxiety convictions syllogism, varying in logical validity and SA congruency

Logical status	‘SA congruent’	‘SA non-congruent’
Valid	Others find me less capable than person A	Others find person 1 less capable than person A
	Others find person A less capable than person 1	Others find person A less capable than me
	Others find me less capable than person 1	Others find person 1 less capable than me
Invalid	Others find person 1 less capable than person A	Others find me less capable than person A
	Others find person A less capable than me	Others find person A less capable than person 1
	Others find me less capable than person 1	Others find person 1 less capable than me

**Table 2** Examples of neutral syllogism, varying in reality value and logical validity

Logical status	True	Untrue
Valid	An elephant is bigger than a dog	A mouse is bigger than a dog
	A dog is bigger than a mouse	A dog is bigger than an elephant
	An elephant is bigger than a mouse	A mouse is bigger than an elephant
Invalid	A mouse is bigger than a dog	An elephant is bigger than a dog
	A dog is bigger than an elephant	A dog is bigger than a mouse
	An elephant is bigger than a mouse	A mouse is bigger than an elephant

Believability was rated for each statement by means of a Visual Analogue Scale (VAS). These VAS's were 17 cm in length with 'unbelievable' displayed left of the VAS, and 'believable' right of the VAS. The VAS's were presented below each statement. Participants had to click on a position on the line with the mouse for their answer, with which a vertical dash appeared on the line. Participants could change the position of the dash if they liked. After having completed all four VAS's per screen, participants clicked a 'continue' button for the next screen. The final VAS answers were rescaled into a 0–100 range. Final believability ratings per statement thus ranged from 0 to 100.

### *Fear of Negative Evaluation*

The 12-item brief Fear of Negative Evaluation scale (Leary 1983) was used to measure core concerns of social anxiety. Items of the BFNE (e.g., *I am often afraid that people will notice my shortcomings*) are rated on a 5-point scale (0–4) indicating the self-reported applicability of the items. The scores range between 0 and 48, with 48 indicating extreme fear of negative evaluation. The BFNE discriminates between social anxiety disorder and panic disorder and also has good concurrent validity (Collins et al. 2005). Internal consistency in the present sample was high at mass-screening (Cronbach's  $\alpha = .97$ ,  $n = 52$ ), as well as during the experiment (Cronbach's  $\alpha = .94$ ,  $n = 52$ ).

### *Procedure*

Experimenters were blind to the participants' fear of negative evaluation pre-test scores. The participants were tested in small groups (one to six participants). Participants

were asked to start the computer programme. They were instructed to judge the validity of the syllogisms as quickly as possible by pressing a red 'NO' key on the left side of the keyboard or a green 'YES' key on the right. Participants were given four practice items with feedback on the correctness of their answers. Further explanation of the validity of the conclusion was given for the first and second practice items. The instructions were repeated at the start of each block. Each stimulus was preceded by a blank screen (500 ms) and a screen reading 'pay attention!' (1,500 ms). Each stimulus disappeared as soon as a response was given, with a maximum of 20 s. If no response was given within this interval, it was treated as an incorrect response. After participants had completed the syllogistic reasoning task, they completed the belief check, after which they filled out a hardcopy version of the BFNE and were debriefed.

### *Data Analysis*

The outcome measures of the syllogistic reasoning task were computed by averaging the median RTs of the four blocks. For errors, the sum of errors over the blocks was computed. As reaction times have a fixed cut-off point (0 s or close to 0 s, depending upon the task that needs to be performed) possible skewness of the RT data was anticipated. It was therefore planned to use square rooted RT as outcome measure.

Although the study was initially designed to compare a high and a low anxious group, the participants showed a continuous rather than dichotomous distribution of BFNE scores (see participants section). To retain optimal power, the full range of scores was used, treating BFNE as a continuous measure of social anxiety. As such, our



hypotheses had to be translated to fit the current design: More belief bias for social anxiety congruent materials with increasing BFNE scores is expected. In addition, it was explored whether belief bias for neutral common knowledge materials increases with BFNE scores. Accordingly, the RT/error data were subjected to a multi-level regression analysis using the MLwiN programme (see <http://www.cmm.bristol.ac.uk/MLwiN/index.shtml>; Rasbash et al. 2004).

All multilevel models were fitted with ‘measures per subject’ as level one, and ‘subject’ as level two. The within-subject variables were dummy coded: SAcongruency 0 (SA non-congruent) and 1 (SA congruent); reality 0 (untrue) and 1 (true); validity 0 (invalid) and 1 (valid). BFNE \* within-subject effects were also computed. For each category, two multilevel models were compared by means of a  $\chi^2$  likelihood ratio test; the basic model which appreciates the experimental within-subject structure but ignores the potential influence of BFNE (see Table 3, Eqs. 1 and 3 for the basic model of the social anxiety convictions and the neutral common knowledge category, respectively), and the hypothesized BFNE-interaction model including both the experimental within-subject structure and its potential interaction with the BFNE (see Table 3, Eqs. 2 and 4 for the BFNE-interaction model of the social anxiety convictions and the neutral common knowledge category, respectively). For each category, it was evaluated which model fitted the data best. Within the best fitting model, the predictors were examined by means of *t*-tests. For the social anxiety conviction syllogisms, our hypothesis refers to a better fit of the BFNE-interaction model, and within this model, a significant contribution of the BFNE \* SAcongruency \* validity interaction to the prediction. For the neutral common knowledge syllogisms it was explored whether the fit improves when including

the BFNE-interaction and, if so, whether the BFNE \* reality \* validity interaction significantly contributes to the prediction. For all tests, a critical value of  $\alpha = .05$  was adopted, one-sided for  $\chi^2$ -tests and *t*-tests.

## Results

### Belief Check

The believability scores of the social anxiety themes were calculated by subtracting the believability rating of the congruent conclusion from the non-congruent conclusion per theme, so that negative scores reflected negative, social anxiety congruent, views. For each theme, the believability scores for the public self-referent and the private self-referent perspective were averaged, resulting in eight believability scores. Also, an overall believability score was calculated by averaging all believability scores.

Cronbach’s alpha was computed to determine the internal consistency of the eight themes, which proved to be good ( $\alpha = .86$ ). Supporting the validity of the present stimulus materials, the overall believability score correlated significantly with the BFNE scores ( $r = -.39$ ,  $p = .004$ ).

### Syllogistic Reasoning Task

As expected, the RT data showed both significant skewness and kurtosis for some cells of the design. Normality was improved by square-root transformation of the RT data, but there were still some mild violations of kurtosis and skewness (the highest kurtosis was reduced from  $z_{\text{kurtosis}} = 7.6$  to  $z_{\text{kurtosis}} = 4.9$ , and the highest skewness from  $z_{\text{skewness}} = 5.6$  to  $z_{\text{skewness}} = 3.5$ ). Details about the distributions can be obtained from the first author on request.

**Table 3** The basic model and the BFNE-interaction model for the common knowledge and the convictions domain used in the multilevel analyses

	Basic model		BFNE-interaction model	
Social anxiety convictions category	Square-root Reaction time (ms) <sub>ij</sub>	(1)	Square-root Reaction time (ms) <sub>ij</sub>	(2)
	= $\beta_{0ij}\text{constant} + \beta_1\text{SAcongruency}_{ij}$ + $\beta_2\text{validity}_{ij}$ + $\beta_3\text{SAcongruency} * \text{validity}_{ij}$ + $u_{0j} + \varepsilon_{ij}$		= $\beta_{0ij}\text{constant} + \beta_1\text{SAcongruency}_{ij} + \beta_2\text{validity}_{ij}$ + $\beta_3\text{SAcongruency} * \text{validity}_{ij} + \beta_4\text{BFNE}_j$ + $\beta_5\text{BFNE} * \text{SAcongruency}_{ij} + \beta_6\text{BFNE} * \text{validity}_{ij}$ + $\beta_7\text{BFNE} * \text{SAcongruency} * \text{validity}_{ij} + u_{0j} + \varepsilon_{ij}$	
Neutral common knowledge category	Square-root Reaction time (ms) <sub>ij</sub>	(3)	Square-root Reaction time (ms) <sub>ij</sub>	(4)
	= $\beta_{0ij}\text{constant} + \beta_1\text{reality}_{ij}$ + $\beta_2\text{validity}_{ij} + \beta_3\text{reality} * \text{validity}_{ij}$ + $u_{0j} + \varepsilon_{ij}$		= $\beta_{0ij}\text{constant} + \beta_1\text{reality}_{ij} + \beta_2\text{validity}_{ij}$ + $\beta_3\text{reality} * \text{validity}_{ij} + \beta_4\text{BFNE}_j$ + $\beta_5\text{BFNE} * \text{reality}_{ij} + \beta_6\text{BFNE} * \text{validity}_{ij}$ + $\beta_7\text{BFNE} * \text{reality} * \text{validity}_{ij} + u_{0j} + \varepsilon_{ij}$	

The error rate was too low to be meaningfully subjected to statistical analysis (cf. de Jong et al. 1997). Hence statistical analysis was restricted to the RT data.

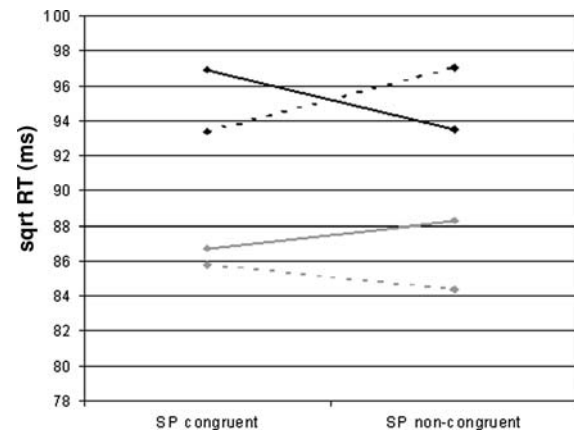
### Social Anxiety Convictions Syllogisms

The BFNE-interaction model produced a significantly better fit over the basic model:  $\chi^2$  difference (4) = 10.029,  $p = .040$ . The BFNE-interaction model best represents the data and looks as follows:

$$\begin{aligned} \text{Square-root Reaction time (ms)}_{ij} &= 88.190(3.297)_{ij}\text{constant} \\ &+ -1.675(1.826)\text{SAcongruency}_{ij} \\ &+ -4.116(1.826)\text{validity}_{ij} \\ &+ 3.257(2.583)\text{SAcongruency} * \text{validity}_{ij} \\ &+ 0.126(0.130)\text{BFNE}_j \\ &+ 0.121(0.072)\text{BFNE} * \text{SAcongruency}_{ij} \\ &+ 0.183(0.072)\text{BFNE} * \text{validity}_{ij} \\ &+ -0.247(0.102)\text{BFNE} * \text{SAcongruency} * \text{validity}_{ij} \\ &+ u_{0j} + \varepsilon_{ij}. \end{aligned} \quad (5)$$

Most importantly, the BFNE \* SAcongruency \* validity interaction dummy contributes significantly to the prediction ( $t(200) = -2.422$ ,  $p = .008$ ). The main effect of BFNE is not significant, but the BFNE \* validity interaction dummy and the BFNE \* SAcongruency interaction dummy are ( $t(200) = 2.542$ ,  $p = .006$  and  $t(200) = 1.681$ ,  $p = .047$ , respectively). Furthermore, the dummy for validity is also significant ( $t(200) = -2.281$ ,  $p = .012$ ), with SA non-congruent-valid syllogisms being solved slightly faster than SA non-congruent-invalid syllogisms, while the SAcongruency \* validity interaction dummy and the SAcongruency dummy are not significant. To be able to interpret the direction of the BFNE-interaction effects, the equation was solved for our lowest and highest scoring participant (BFNE = 1 and BFNE = 42, respectively). The resulting patterns can be seen in Fig. 1. There is a clear belief bias effect for high scorers (faster responses when there is a match between the conclusions' congruency with social anxiety-relevant convictions and the conclusions' logical validity), and no belief bias effect for low scorers.<sup>6</sup>

<sup>6</sup> When taking the two perspectives (public and private self-referent) apart, treating them as a third within-subject factor, multilevel analysis shows no significant BFNE \* SAcongruency \* validity \* perspective interaction ( $t(192) = 0.240$ ,  $p = .405$ ), indicating that the two perspectives show a similar pattern of belief bias dependent on BFNE.



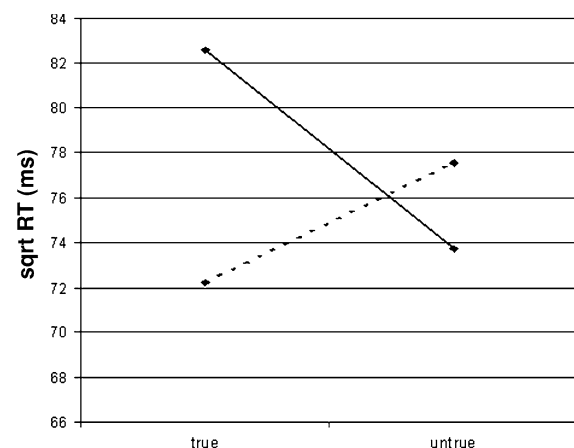
**Fig. 1** Square-rooted RTs (ms) on the four conditions of the social anxiety convictions domain for the lowest (BFNE = 1) and the highest (BFNE = 42) socially fearful participants, illustrating the SAcongruency \* validity \* BFNE interaction. —○— BFNE = 1, valid; —○— BFNE = 1, invalid; —●— BFNE = 42, valid; —●— BFNE = 42, invalid

### Neutral Common Knowledge Syllogisms

The BFNE-interaction model did not produce a significantly better fit over the basic model:  $\chi^2$  difference (4) = 3.774,  $p = .437$ . The basic model best represents the data and looks as follows:

$$\begin{aligned} \text{Square-root Reaction time (ms)}_{ij} &= 73.750(1.474)_{ij}\text{constant} + 8.846(1.086)\text{reality}_{ij} \\ &+ 3.788(1.086)\text{validity}_{ij} + -14.154(1.536) \\ &\times \text{reality} * \text{validity}_{ij} + u_{0j} + \varepsilon_{ij}. \end{aligned} \quad (6)$$

There is a significant reality \* validity interaction dummy ( $t(204) = -9.215$ ,  $p < .001$ ), and solving the equation shows that this interaction-effect is indeed the hypothesized belief bias effect, see Fig. 2. This interaction was not



**Fig. 2** Square-rooted mean median RTs (ms) on the four conditions of the neutral syllogisms. —●— valid; —●— invalid

influenced by the BFNE scores. Thus, there was no evidence supporting the idea that highly socially anxious participants display an increased general belief bias. The dummy for reality was significant,  $t(204) = 8.145$ ,  $p < .001$ . On trials representing syllogisms that are invalid, true syllogisms (mismatched syllogisms, true-invalid) took longer to be solved than untrue syllogisms (matched syllogisms, untrue-invalid). The dummy for validity was also significant,  $t(204) = 3.488$ ,  $p < .001$ . For trials representing syllogisms that are untrue, valid syllogisms (mismatched syllogisms, untrue-valid) take longer to solve than invalid syllogisms (matched syllogisms, untrue-invalid).

### *Additional Analysis*

During the debriefing procedure, some participants indicated that they found the syllogistic reasoning task was too long. In light of future use of this task, the data were therefore re-analyzed using only the first half of the task (given the counterbalanced presentation of syllogisms over the blocks, this does not result in a different or unbalanced design). The results were similar to those obtained using all stimuli: the BFNE-interaction model was superior to the basic model for the social anxiety convictions category ( $\chi^2$  difference (4) = 10.914,  $p = .028$ ), and the BFNE \* SA-congruency \* validity interaction dummy in this model proved significant (parameter-estimate:  $-0.250$ ,  $t(200) = -1.852$ ,  $p = .033$ ). The BFNE-interaction model was not superior to the basic model for the neutral common knowledge category ( $\chi^2$  difference (4) = 13.427,  $p = .009$ ), and therefore there was no BFNE \* reality \* validity interaction.

### **Discussion**

This study investigated the relationship between belief bias and social anxiety. Although the study was initially designed to compare a high and low anxiety group, a shift in design had to be made due to the change in BFNE scores after preselection. Instead of making group comparisons, it was tested whether belief bias increased with increasing BFNE scores. Furthermore, the analyses were restricted to the RT data, as the error rates and the dispersion were too low to be analysed. The low error rates indicate that participants confirmed to the task and did not show response biases. The main results can be summarized as follows. First, for the social anxiety relevant materials, results indicated that the higher participants' fear of negative evaluation, the stronger the belief bias effect. Second, for the neutral common knowledge syllogisms, there was an overall belief bias effect that was independent of participants' fear of negative evaluation.

According to contemporary cognitive models of anxiety disorders, persistent dysfunctional cognitions (such as 'If I make a mistake, people will make fun of me') play a vital role in the maintenance of complaints (e.g., Beck et al. 1985; Clark and Wells 1995; Rapee and Heimberg 1997). One obvious explanation for the refractoriness of this type of anxiogenic convictions is that socially anxious individuals are actually evaluated less positively than non-anxious individuals, for example because they behave less skilful in social situations. In line with this, there are indications that in some situations people suffering from social anxiety may indeed perform less well than non-anxious controls (e.g., Stopa and Clark 1993; Voncken and Bögels 2008). This does not however imply that the convictions of social anxiety patients are necessarily true, as these oftentimes concern blunt negative appraisal or rejection by others. Another mechanism that may play a fairly direct role in the persistence of these anxiogenic convictions concerns individuals' difficulty to correct their dysfunctional convictions when confronted with disconfirming evidence. Correcting erroneous convictions requires the ability to accurately deduce the logical implications of empirical evidence for certain convictions. For instance, not being made fun of after having made a public mistake should lead to correction of the dysfunctional belief 'If I make a mistake, people will make fun of me', since it proves that the cognition is invalid. In support of the hypothesis that belief bias may be involved in social anxiety, the results for the RT data showed that individuals high in fear of negative evaluation have relative difficulty in judging anxiogenic (i.e., social anxiety congruent) information as false and reassuring non-congruent information as true. Such a belief bias effect for social anxiety convictions logically prevents dysfunctional cognitions from being corrected, thereby sustaining phobic fear.

It should be acknowledged that belief bias theory concerns errors in reasoning. In the present study we used linear syllogisms that are known to be relatively easy and to produce little errors (Huttenlocher 1968). Indeed, in line with previous research using this type of syllogisms (e.g., de Jong et al. 1997), participants in this study made only few errors. This implies that the participants actually reasoned analytically when performing the task. In this study, a belief bias effect for RTs was found in a single-task situation where all resources could be employed to the task. With all resources available, the participants needed more time to answer the mismatched syllogisms, indicating that it took more effort and/or resources to answer these syllogisms. It seems safe to assume that when reasoning takes more effort in a lab, it will result in faulty reasoning when sufficient cognitive resources and/or the motivation to reflect on the validity of their initial convictions are lacking, which is likely to be the case in most real life situations



(e.g., Beevers 2005; Evans and Curtis-Holmes 2005). Obviously, further research manipulating the availability of cognitive resources is necessary to arrive at more final conclusions in this respect.

The absence of a relationship between belief bias for neutral common knowledge and fear of negative evaluation indicates that anxious individuals are not characterized by a reasoning abnormality and that the belief bias for social anxiety convictions that was found in the present study reflects a normal tendency to reason in a belief biased manner with respect to strongly held convictions.<sup>7</sup> This belief bias for social anxiety convictions is merely problematic because it logically acts to maintain convictions that are *dysfunctional*.

The finding of complaint-related belief bias for individuals who are fearful of negative evaluation is an important first step in determining whether belief bias may indeed be involved in the maintenance of social anxiety disorder. Meanwhile, it should be acknowledged that on the basis of the present study it cannot be ruled out that this belief bias for social anxiety convictions is a mere symptom of social anxiety rather than a mechanism that reciprocally strengthens the dysfunctional convictions. While causality problems of the present type are hard to solve, they are theoretically important. As a next step it would be worthwhile investigating whether post-treatment belief bias is predictive of relapse after successful treatment (cf. de Jong et al. 1995). If not, causality seems highly unlikely. A more direct and rigorous way to test the causal properties of belief bias would be to specifically reduce belief bias and to test whether this results in a reduction of dysfunctional beliefs and symptoms of social anxiety (cf. MacLeod et al. 2002). Perhaps most relevant to the clinical context is the question whether enhanced belief bias present after successful treatment of the social anxiety disorder can predict relapse. If the complaints have disappeared, but social anxiety related belief bias is still present, this belief bias potentially indicates that the patient still holds social anxiety related convictions. As such, the belief bias task may serve as an implicit measure to detect such (potentially unreported) remaining beliefs. Of course, further research is required to actually test these notions.

It is a well-established fact that the belief bias theory holds for common knowledge and commonly shared prejudices (e.g., Evans et al. 1993a). The current study illustrates that belief bias effects can also be found for irrational convictions for which disconfirming evidence is available. The finding that correct information does not

necessarily result in disconfirmation of irrational convictions emphasizes the difficulty for people to reason following logical rules. This underscores the importance of explicitly discussing the arguments for and against dysfunctional convictions in the context of behavioural experiments as a way to help patients to detect the relevant premises or arguments for their dysfunctional conclusion.

## Limitations

Although the correlation between the believability check and the BFNE was significant and supports the validity of the stimulus materials that were used, the modest strength of the association suggests that there is also still room to further improve the validity of the stimulus material and thereby the sensitivity of the present belief bias task. It should be acknowledged that global social anxiety themes were used. The validity of the task may be enhanced by adjusting the syllogisms to individuals' core beliefs. In addition, the construction of linear syllogisms required the inclusion of abstract contrasts (e.g., *I am less socially skilled than person A* and *person A is less socially skilled than person I*) which might have resulted in a suboptimal reflection of the individual's actual convictions. Future research may need to search for different paradigms to measure belief bias which allow for a better match of the materials with the actual convictions.

There was a discrepancy between the BFNE scores during the mass-screening and during the experiment proper. This could raise some doubts concerning the reliability and validity of our screening instrument. Yet, the reliability scores of both test administrations were high. Hence, there is reason to suspect that the changes in scores reflect real changes in social anxiety rather than a statistical artifact (cf. Dijk and de Jong, *in press*) or unreliability of the BFNE. Ample new social experiences associated with starting a new life as a student could potentially explain the unexpected deviance in FNE scores between the mass-screening and the actual experiment. These change in BFNE scores interfered with our planned factorial approach. Fortunately, the range and distribution of BFNE scores during the actual experiment allowed us to test our hypotheses while maintaining the continuity of our data, resulting in a relatively powerful design.

Another point of attention lies in the use of the BFNE as a measure of social anxiety. There have been some concerns with the use of BFNE as a measure of social anxiety, given that it only measures beliefs and not behaviours (Wilson and Rapee 2005). On the other hand, Collins et al. (2005) and Weeks et al. (2005) have found that the BFNE is a valid measure for clinical social anxiety groups. In addition, Stopa and Clark (2001) showed that for

<sup>7</sup> Based on the current design, it cannot be ruled out that high socially anxious people display a stronger belief bias for all sorts of convictions (e.g., prejudices) than low anxious people. This would however not alter the interpretation of the current findings.

psychological process studies, an analogue design based on BFNE-scores produces findings that are essentially the same as those found in studies using social anxiety disordered patients and non-clinical controls. The results of the current study can be potentially relevant to other patient groups as well: Studies using different analogue or patient groups such as eating disorders have found correlations between the BFNE and self-reported eating disorder and depressive complaints (e.g., Gilbert and Meyer 2003; Hinrichsen et al. 2003). On the other hand, both eating disorder and depression self-report questionnaires are known to correlate with other measures of social anxiety complaints as well (e.g., Gibb et al. 2005; Hinrichsen et al. 2004), and both disorders are found to have high comorbidity with social anxiety disorder (e.g., Kessler 1995; Pallister and Waller 2008). Whether the results of the current study can be generalized to disorders such as depression and eating disorder remains to be seen.

The order of the BFNE and the syllogistic reasoning task was not counterbalanced over participants. The BFNE was always administered after completion of the reasoning task. This was done to avoid potential priming effects of the BFNE on the reasoning task (cf. Bosson et al. 2000), however this procedure may have enhanced existing individual differences in BFNE scores.

A final remark concerns the generalisation of the current findings. It remains to be seen whether similar findings will be obtained in a more male/female balanced group, as well

as in less highly educated groups. In addition, the present study relied on an analogue sample, and it remains therefore to be seen whether similar findings will be obtained in treatment seeking individuals suffering from a clinically diagnosed social anxiety disorder.

## Conclusion

The present study supports the potential importance of belief bias in the maintenance of social anxiety disorder. Future studies are necessary to investigate whether the present effects can be replicated with patients suffering from social anxiety disorder or other forms of psychopathology in which dysfunctional cognitions are assumed to play a critical role, such as depression, and to test the alleged causality of this bias in maintaining and developing psychopathological complaints.

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## Appendices

### Appendix 1 Linear syllogisms; social anxiety convictions category

Syllogism content	Conclusion
I < person A < person 1 (less capable)	I am less capable than person 1 Others find me less capable than person 1
I < person A < person 1 (less skilled socially)	I am less skilled socially than person 1 Others find me less skilled socially than person 1
Person A > person 1 > me (more spontaneous)	Person A is more spontaneous than me Others find person A more spontaneous than me
I > person A > person 1 (ridiculed)	I feel ridiculed more quickly than person 1 Others ridicule me more quickly than person 1
I > person A > person 1 (rejected)	I feel rejected more quickly than person 1 Others reject me more quickly than person 1
Person A > person 1 > me (more interesting)	Person A is more interesting than me Others find person A more interesting than me
Person A > person 1 > me (taken seriously)	Person A feels taken seriously more often than me Others take person A seriously more often than me
I > person 1 > person A (looked at)	I feel looked at more quickly than person A Others look at me more quickly than at person A

*Note.* The syllogisms were varied in congruency and validity. Only the congruent with SA and valid syllogisms are presented in the table

**Appendix 2** Linear syllogisms; neutral category

Syllogism content	Conclusion
Elephant > dog > fly (bigger)	An elephant is bigger than a fly
Scooter < car < airplane (smaller)	A scooter is smaller than an airplane
House > bicycle > apple (expensive)	A house is more expensive than an apple
Leopard > human being > snail (faster)	A leopard is faster than a snail
Lamppost > broom > pen (bigger)	A lamppost is bigger than a pen
Car > moped > bicycle (faster)	A car is faster than a bicycle
SAHARA > Spain > Iceland (warmer)	The Sahara is warmer than Iceland
White < grey < black (lighter)	White is lighter than black

*Note.* The syllogisms were varied in reality value and validity. Only the true and valid syllogisms are presented in the table

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